# CPM-200: Principles of Schedule Management

## Lesson C: Schedule Analysis Techniques

Instructor

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PMI-College of Performance Management faculty

# Lesson Objectives

The student will understand:

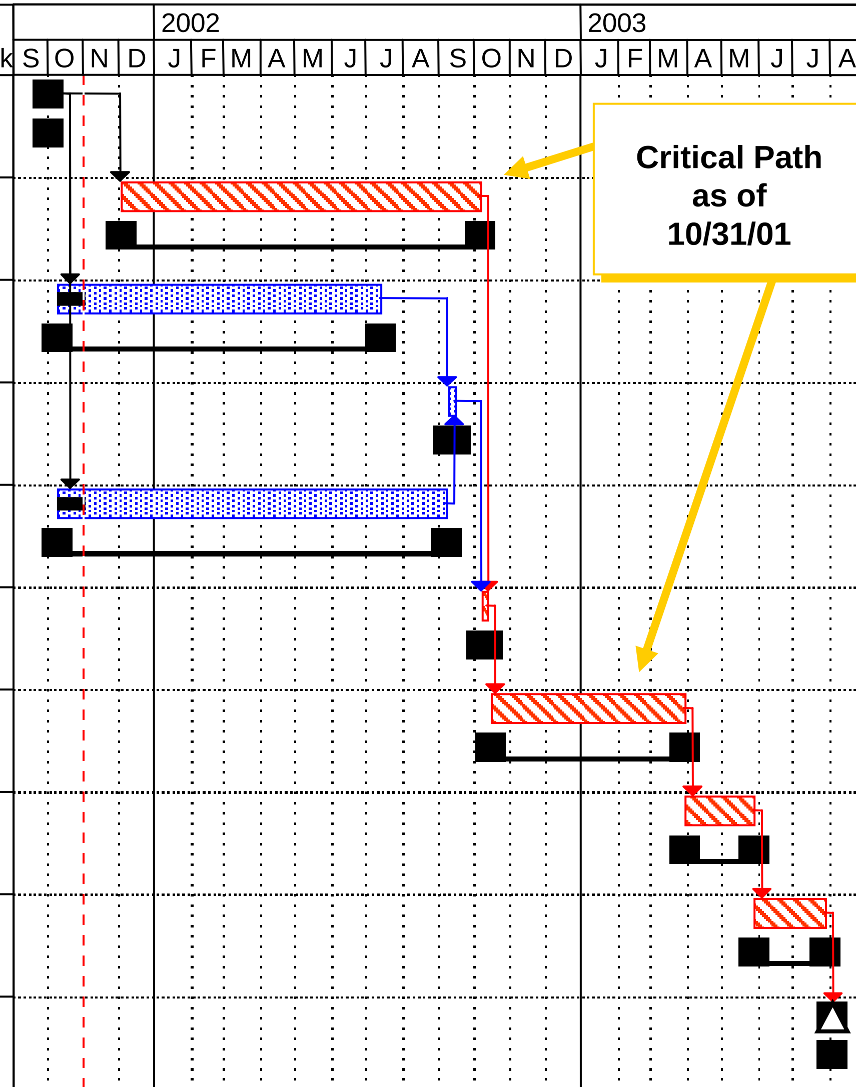
1. What is meant by Schedule Analysis.
2. What insight Schedule Analysis can provide the project team.
3. Why Schedule Analysis is performed.
4. What are some of the basic techniques for performing Schedule Analysis

# This Lesson Will Provide Insight Into:

- **Critical Path:** schedule driver or long pole
- **Accuracy:** correct schedule inputs (activities, durations)
- **Integration:** properly defined interrelationships
- **Realism:** an achievable schedule
- **Performance:** timely, efficient accomplishment of work
- **Variances:** significance of differences from baseline
- **Trends:** direction of the schedule
- **Forecasting:** predicting future schedule performance
- **What-If:** impact of potential problems and changes
- **Risk:** likelihood of overrunning the schedule
- **Resources:** sufficient availability of staff, facilities, etc.

# NBT Project Critical Path last month:
## *– what's the "long pole?"*

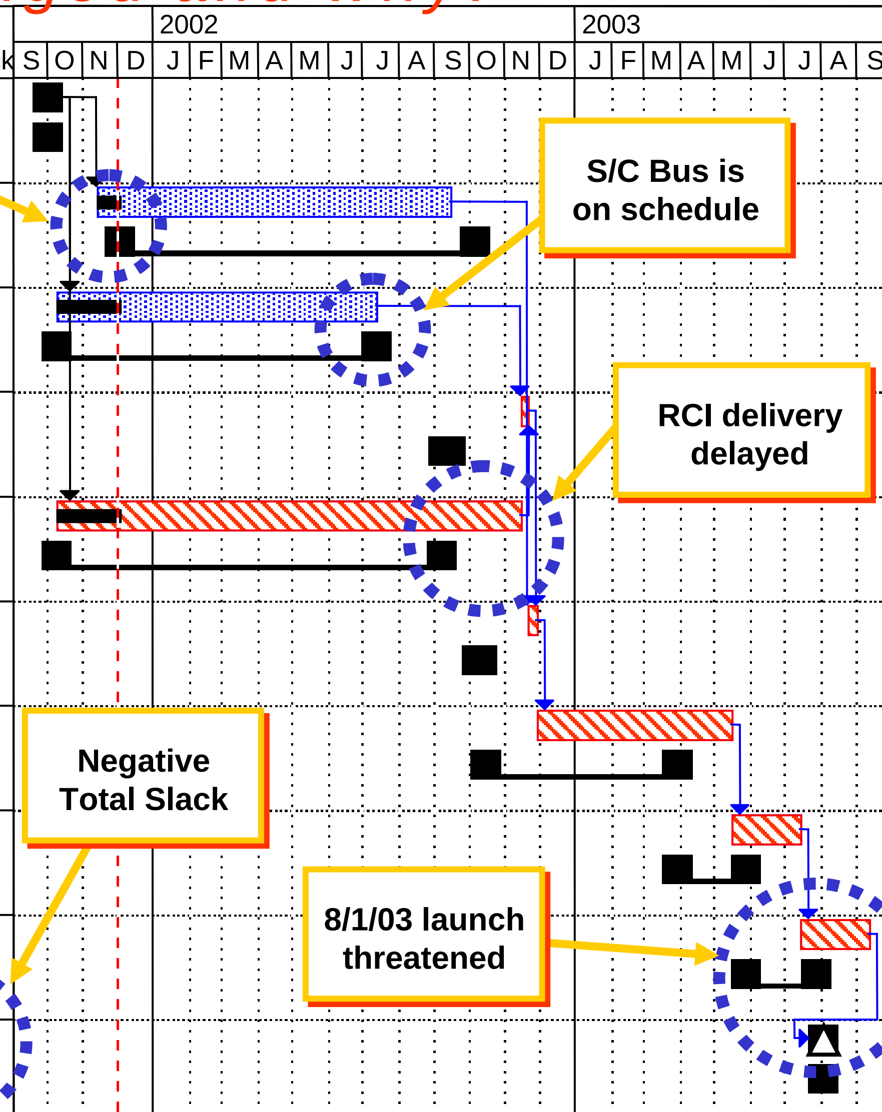
| ID | Activity | Dur | Early Start | Early Finish | Total Slack |
|---|---|---|---|---|---|
| 1 | Authorize Funding | 0 days | 10/1/01 | 10/1/01 | 0 days |
| 2 | Procure VEI Instrument | 220 days | 12/3/01 | 10/4/02 | 4 days |
| 3 | Procure Spacecraft Bus | 200 days | 10/8/01 | 7/12/02 | 59 days |
| 4 | Integrate RCI to Spacecraft | 5 days | 9/9/02 | 9/13/02 | 19 days |
| 5 | Develop RCI Instrument | 240 days | 10/8/01 | 9/6/02 | 19 days |
| 6 | Integrate VEI to Spacecraft | 5 days | 10/7/02 | 10/11/02 | 4 days |
| 7 | Observatory Testing | 120 days | 10/14/02 | 3/28/03 | 4 days |
| 8 | Schedule Contingency | 60 days | 3/29/03 | 5/27/03 | 6 days |
| 9 | Launch Site Operations | 60 days | 5/28/03 | 7/26/03 | 6 days |
| 10 | Launch | 0 days | 8/1/03 | 8/1/03 | 0 days |




REV: Baseline 8/15/01

# *NBT Project Critical Path this month:*
# *has it changed and why?*

| ID | Activity | Dur | Early Start | Early Finish | Total Slack |
|---|---|---|---|---|---|
| 1 | Authorize Funding | 0 days | 10/1/01 | 10/1/01 | 0 days |
| 2 | Procure VEI Instrument | 220 days | 11/12/01 | [illegible] | [illegible] |
| 3 | Procure Spacecraft Bus | 200 days | 10/8/01 | 7/12/02 | 59 days |
| 4 | Integrate RCI to Spacecraft | 5 days | 11/14/02 | 11/20/02 | -29 days |
| 5 | Develop RCI Instrument | 288 days | 10/8/01 | 11/13/02 | -29 days |
| 6 | Integrate VEI to Spacecraft | 5 days | 11/21/02 | 11/27/02 | -29 days |
| 7 | Observatory Testing | 120 days | 11/28/02 | 5/14/03 | -29 days |
| 8 | Schedule Contingency | 60 days | 5/15/03 | 7/13/03 | -41 days |
| 9 | Launch Site Operations | 60 days | 7/14/03 | 9/11/03 | -41 days |
| 10 | Launch | 0 days | 8/1/03 | 8/1/03 | -41 days |




REV: Baseline 8/15/01

# Schedule Accuracy:
## *is the schedule data correct?*

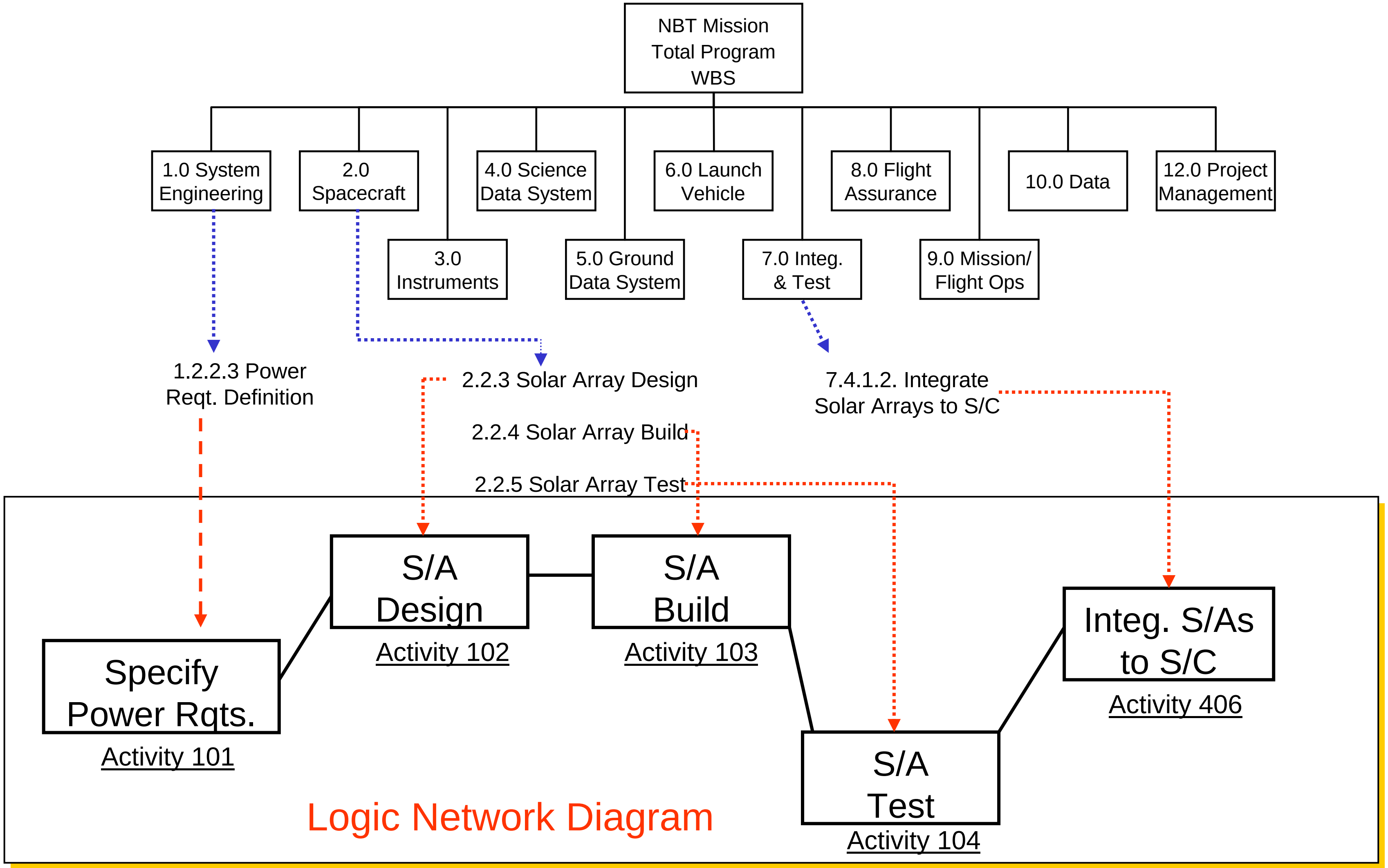
**Schedule Accuracy-** **The primary data used to develop the schedule should be correct and based on reality**

- **Activities capture the entire work scope**
- **Durations are realistic and feasible, not “success-oriented” or “fat”**
- **Assumptions and constraints are legitimate**

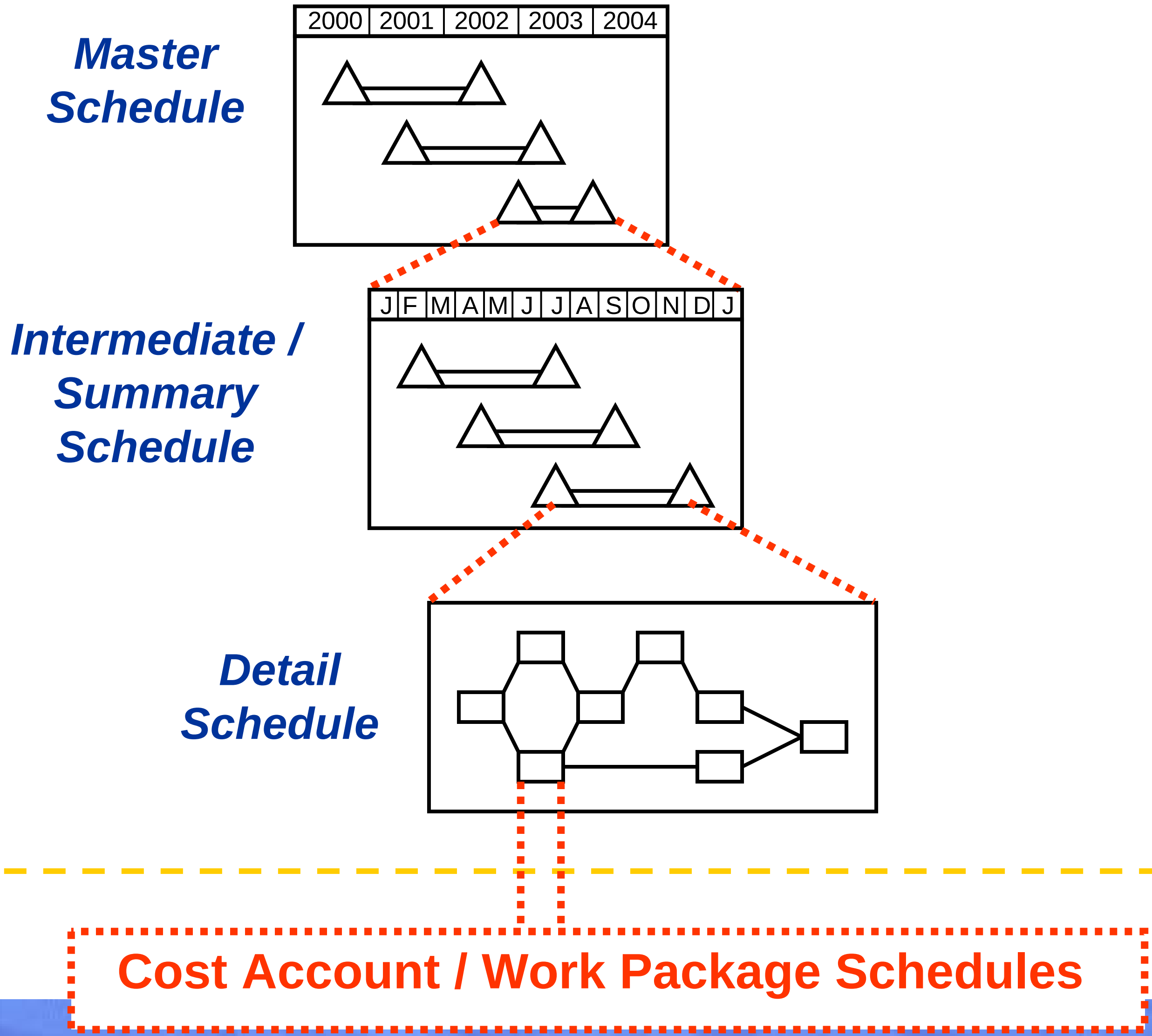
**Analysis Approach:**

- **Verification of activity traceability to project data (e.g. WBS, SOW)**
- **Comparison of current durations to baseline, prior period, “actuals” from similar projects or previous builds, BOEs, supplier lead times, etc.**
- **Verification of schedule assumptions with external agreements such as Memorandums Of Understanding, Letters Of Agreement, contracts & subcontracts, GFE lists, etc.**

# Horizontal Schedule Integration: *is the logic right?*

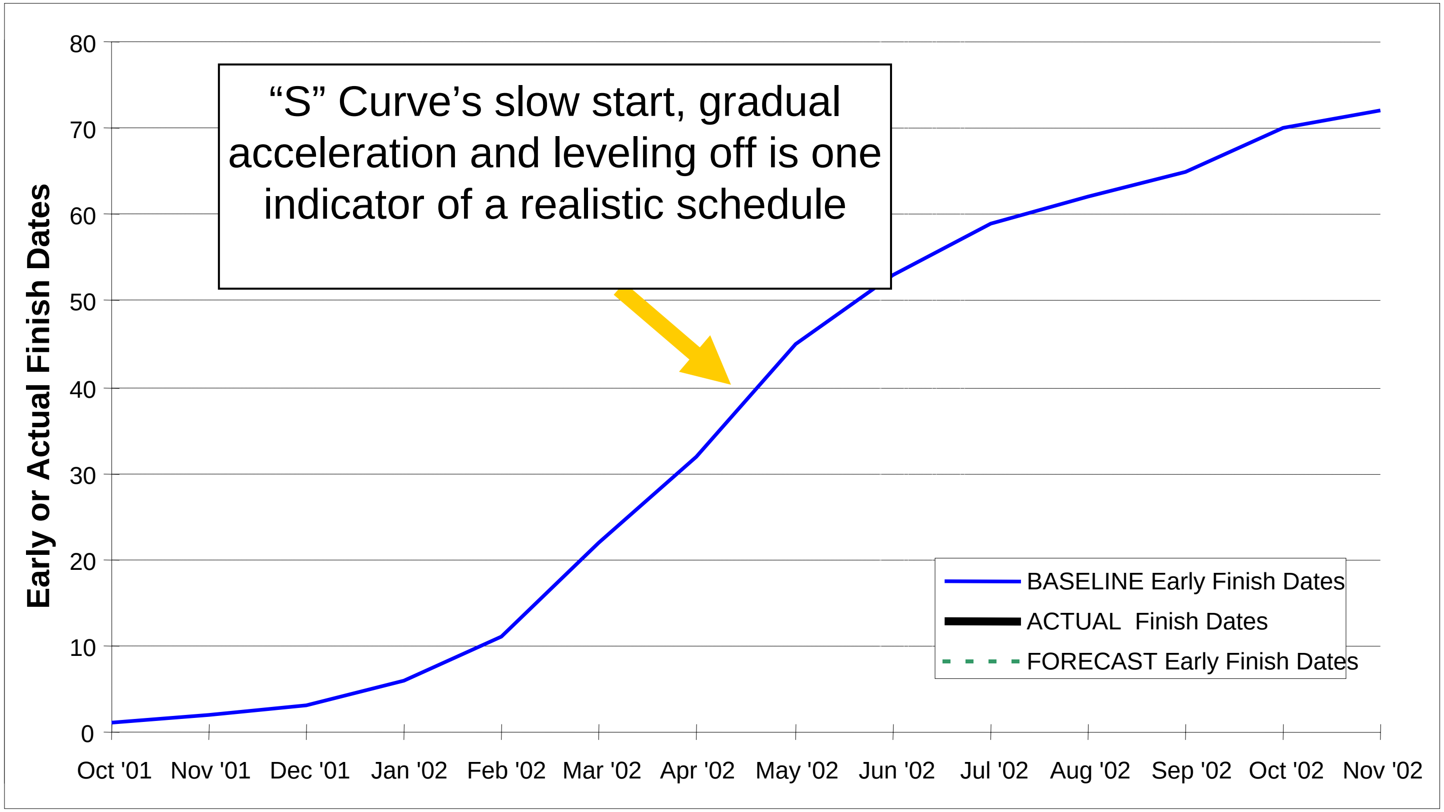


# Vertical Schedule Integration: *is alignment correct?*



# Schedule Realism:
# *is the schedule achievable?*

## NBT Project "Early Finish" Date Baseline Schedule Plan

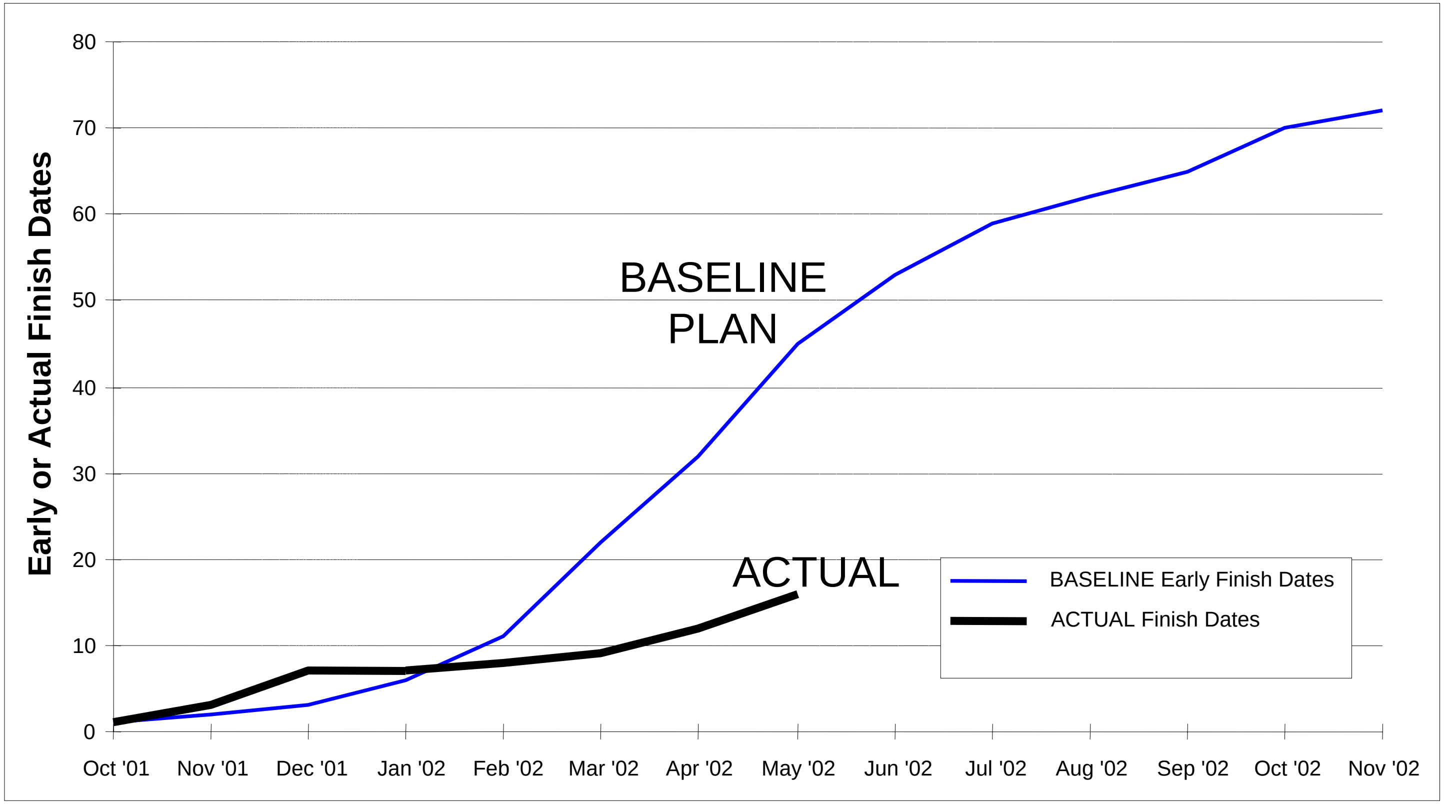



| | Oct '01 | Nov '01 | Dec '01 | Jan '02 | Feb '02 | Mar '02 | Apr '02 | May '02 | Jun '02 | Jul '02 | Aug '02 | Sep '02 | Oct '02 | Nov '02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CUM Baseline** | 1 | 2 | 3 | 6 | 11 | 22 | 32 | 45 | 53 | 59 | 62 | 65 | 70 | 72 |
| **CUM Actual** | | | | | | | | | | | | | | |
| **CUM Forecast** | | | | | | | | | | | | | | |

# Schedule Performance:

# *are activities being accomplished on time?*

## NBT Project Schedule Performance – as of May 30, 2002




| | Oct '01 | Nov '01 | Dec '01 | Jan '02 | Feb '02 | Mar '02 | Apr '02 | May '02 | Jun '02 | Jul '02 | Aug '02 | Sep '02 | Oct '02 | Nov '02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CUM Baseline** | 1 | 2 | 3 | 6 | 11 | 22 | 32 | 45 | 53 | 59 | 62 | 65 | 70 | 72 |
| **CUM Actual** | 1 | 3 | 7 | 7 | 8 | 9 | 12 | 16 | | | | | | |
| | | | | | | | | | | | | | | |

# Schedule Performance:
# *Ratio Analysis Example*

**ASTRO Project Software Module Code & Checkout Completion: As of 5/31/02**

| | 2001 | | | 2002 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov |
| **CUM Baseline** | 1 | 2 | 3 | 6 | 11 | 22 | 32 | 40 | 50 | 59 | 62 | 65 | 67 | 70 |
| **CUM Actual** | 1 | 3 | 7 | 7 | 8 | 15 | 24 | 30 | | | | | | |
| | | | | | | | | | | | | | | |

**TO DATE**

30 modules ÷ 8 months = 3.75 (actual rate)

40 modules ÷ 8 months = 5 (baseline rate)

3.75 ÷ 5 = 75% efficiency-to-date

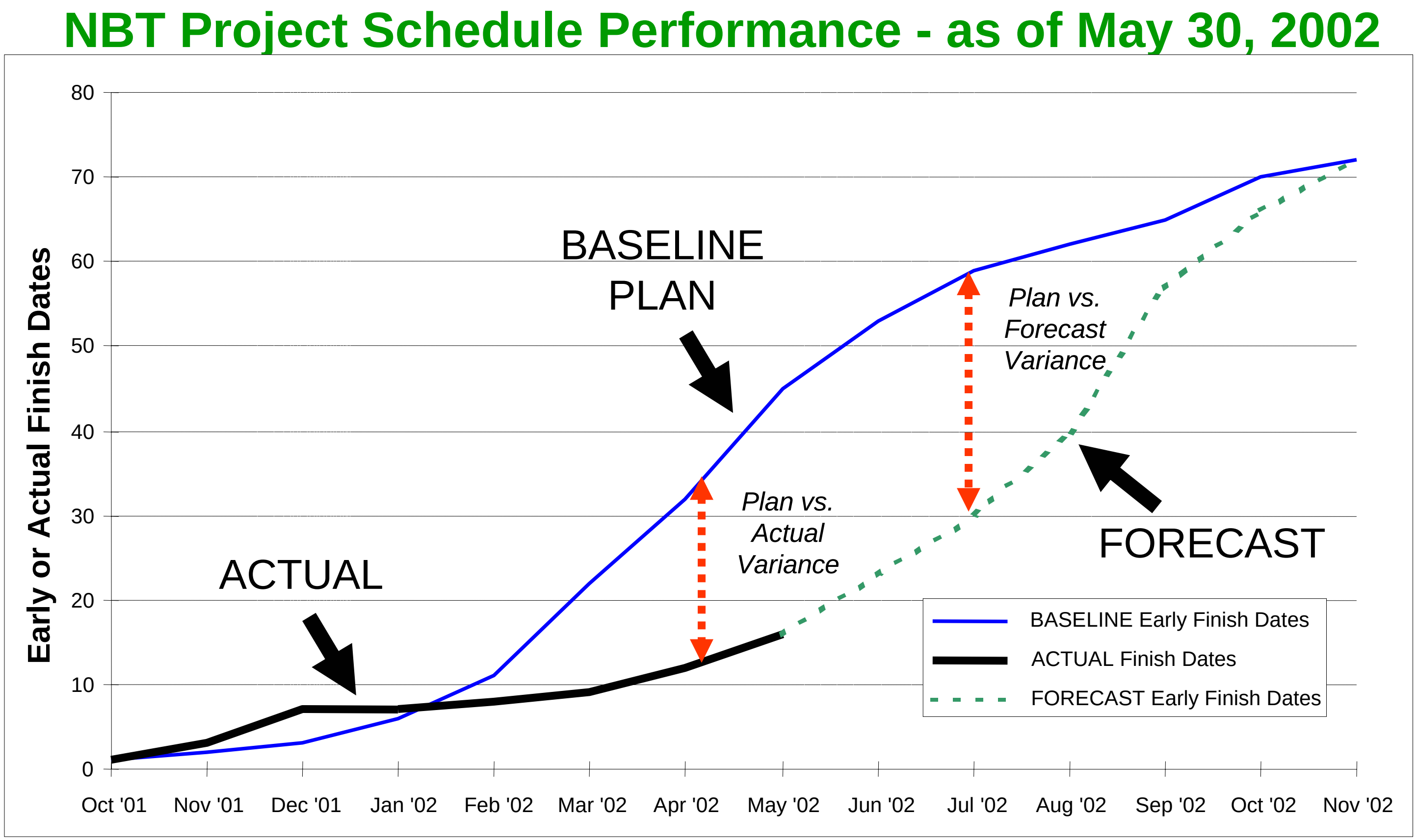
0% - - - - - - - - - - 50% - - - - - - - - - - 100%

Less Efficient ... More Efficient

***To date, schedule efficiency is 75% - the ASTRO software development team is accomplishing, on average, 3/4 of what it planned to do.***

# Schedule Variances:

## *are differences from the baseline significant?*




| | Oct '01 | Nov '01 | Dec '01 | Jan '02 | Feb '02 | Mar '02 | Apr '02 | May '02 | Jun '02 | Jul '02 | Aug '02 | Sep '02 | Oct '02 | Nov '02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CUM Baseline** | 1 | 2 | 3 | 6 | 11 | 22 | 32 | 45 | 53 | 59 | 62 | 65 | 70 | 72 |
| **CUM Actual** | 1 | 3 | 7 | 7 | 8 | 9 | 12 | 16 | | | | | | |
| **CUM Forecast** | | | | | | | | | 23 | 30 | 40 | 57 | 66 | 72 |

# Example Variance Analysis Report

**WBS**: 1.1.2 C&DH Subsystem

1.1.2.2 RTT “B” Assembly

**MILESTONE**: CDH6022 RTT “B” Ready for Observatory Integration & Test

**BASELINE**: 5/28/02

**FORECAST**: 6/7/02

**CAUSE & CORRECTIVE ACTION**:

•Memory anomaly during final test caused a 10 day slip in delivery to I&T, putting the RTT B on the critical path at -5 days total slack.

•A 2nd shift will be added to finish testing.

•I&T Manager can modify I&T work flow to accommodate this delay if necessary.

# Schedule Trends:

## *is the schedule's direction favorable or unfavorable?*

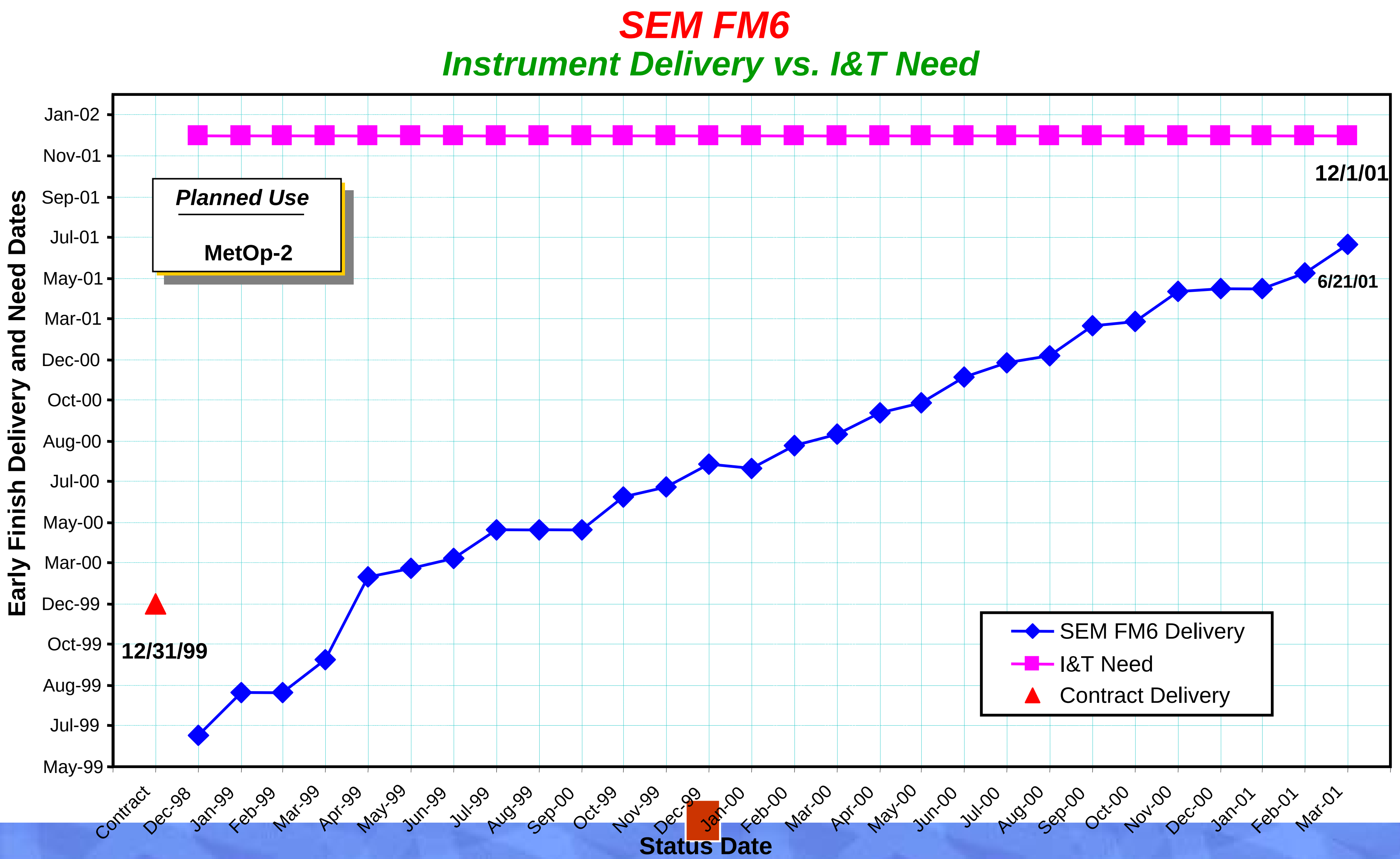
**Schedule Trend(s):**

- **Indicate the schedule's future direction based on historical results**
- **Provide a means to indicate the extent to which actual and predicted performance are diverging from the baseline schedule**

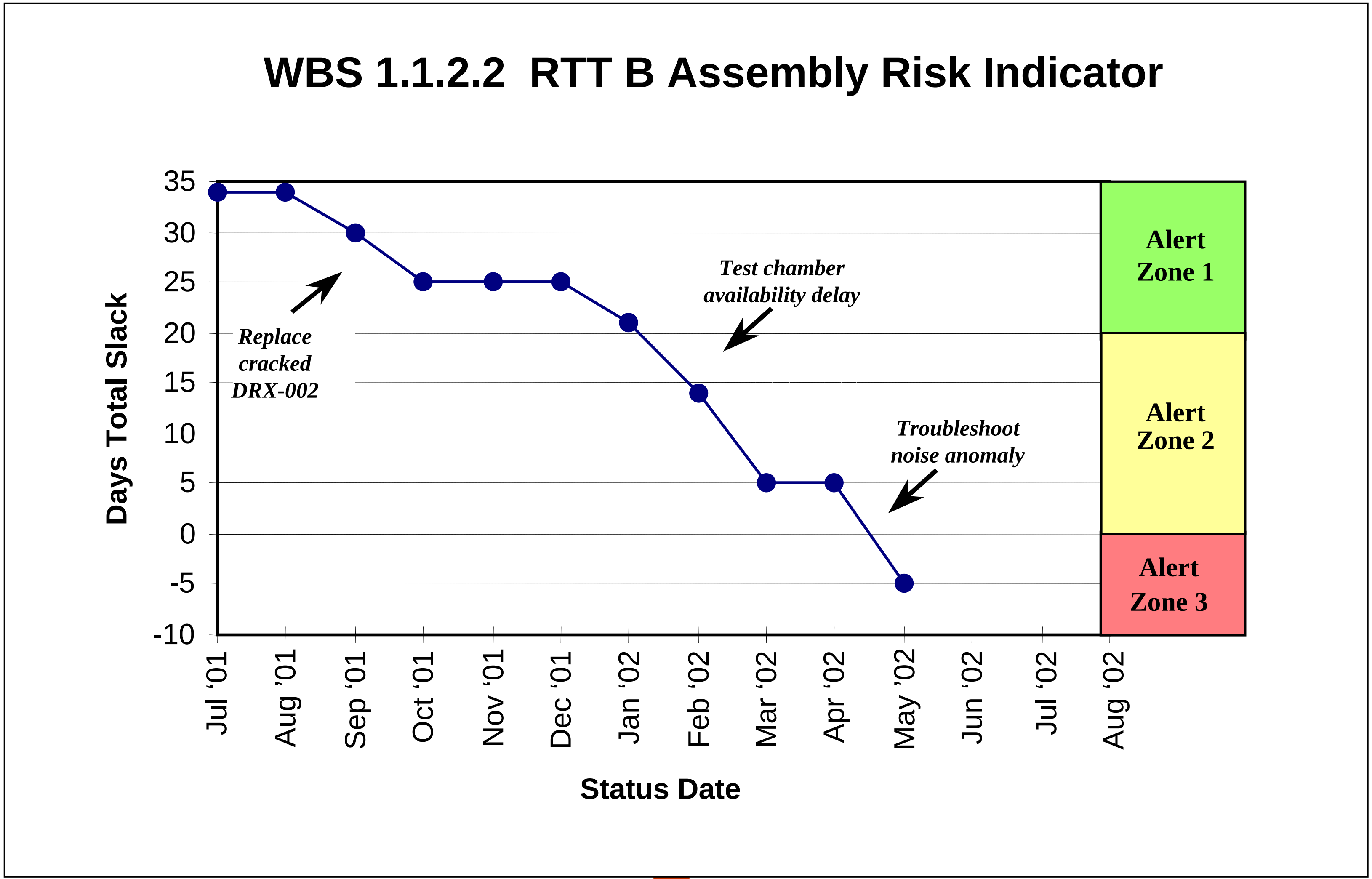
**Analysis Approach:**

- **Performance trends:** **track actual completion of activities and milestones over time to determine if progress is being made**
- **Slack trends:** **track slack depletion over time to assess if sufficient spare time is available or if resources should be reallocated**
- **Reserve trends:** **track reserve consumption over time to determine if it is still sufficient**
- **Delivery trends:** **track projected delivery dates over time to extent of delays or slippages**

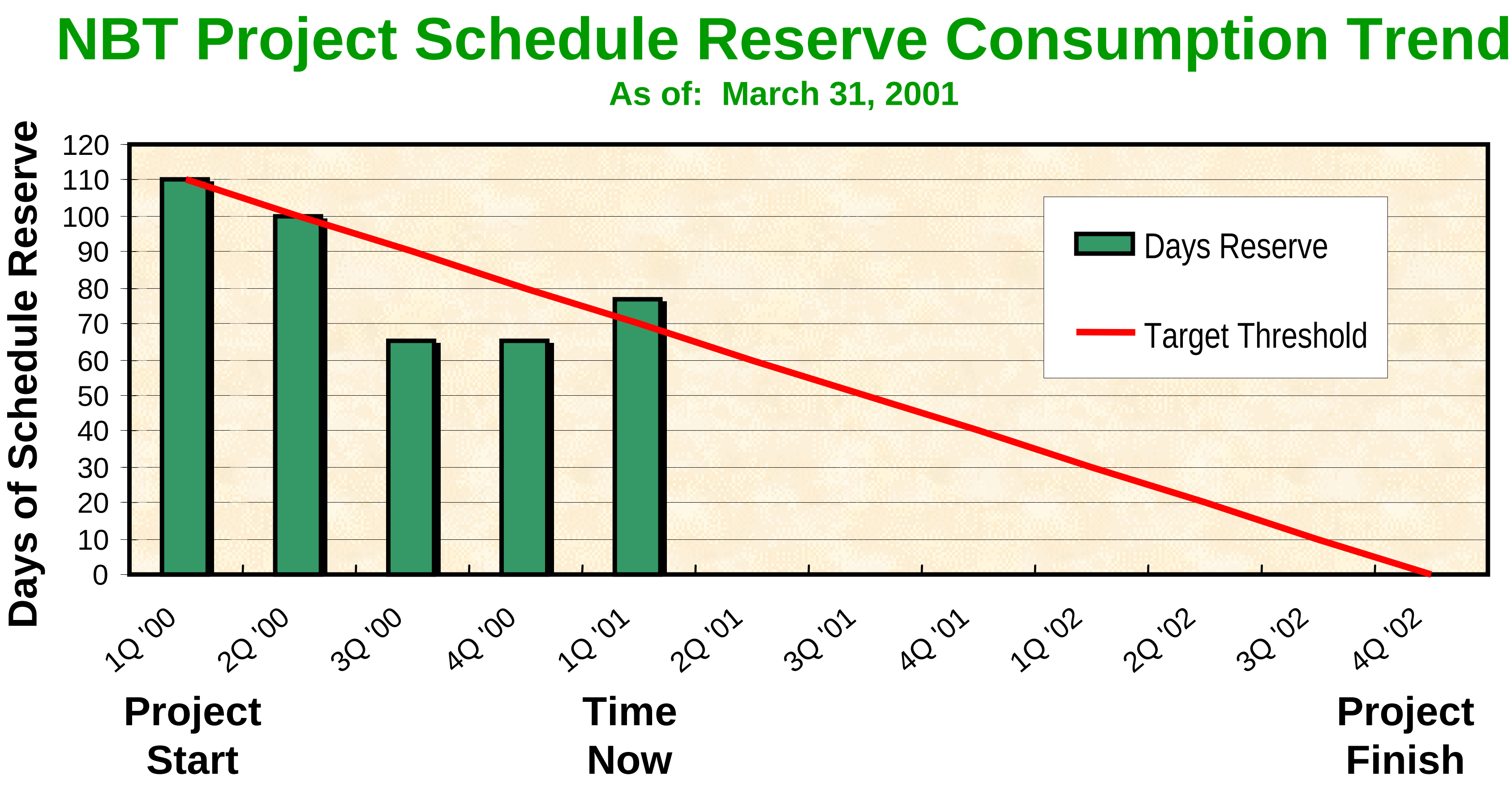
# Delivery Date Trend vs. Need Date Trend



# Example Slack Trend With Risk Thresholds



# Example Schedule Reserve Trend



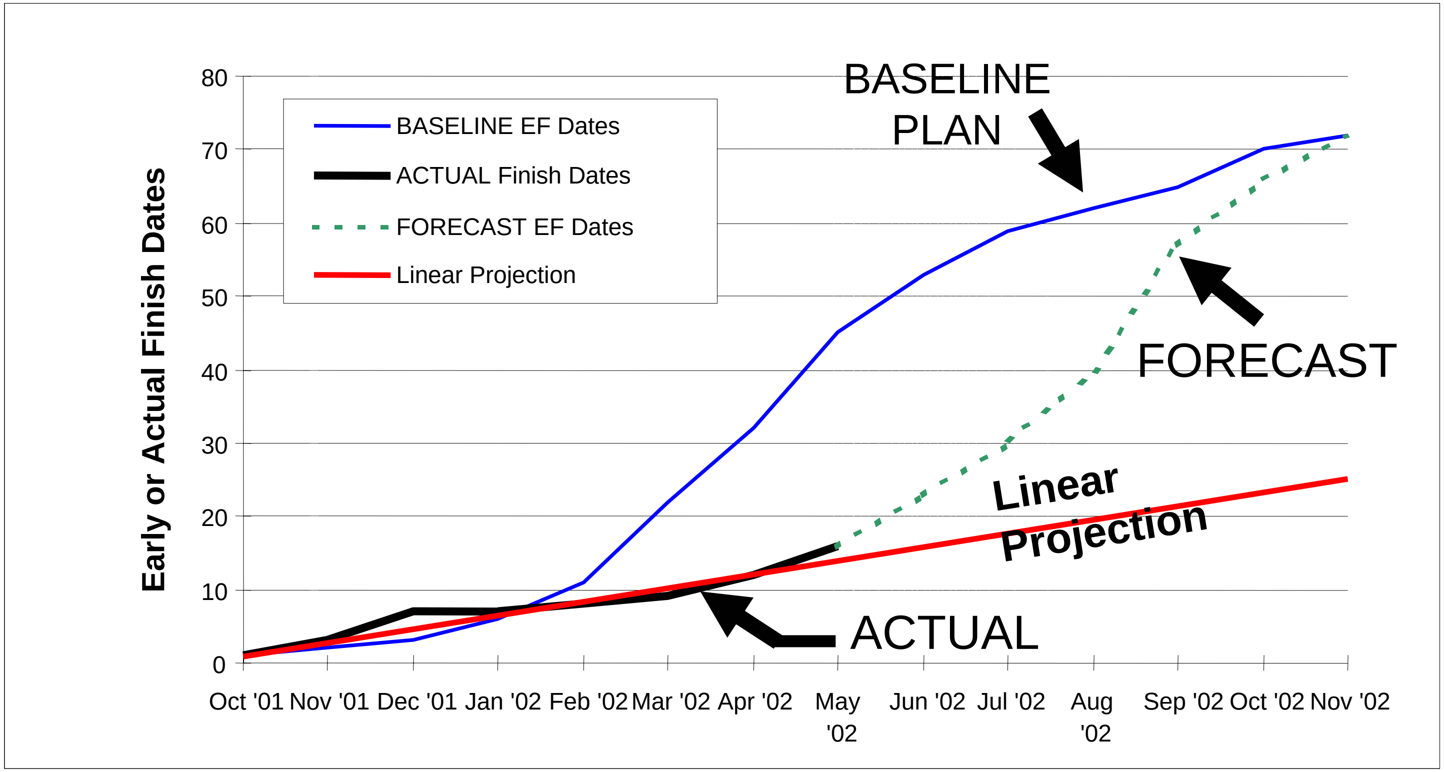
# Risk-Based Schedule Reserve Determination Example

| Activity | Risk | Impact | | Probability | | Expected Value of Reserve |
|---|---|---|---|---|---|---|
| Observatory Mechanical Integration | Late MGSE | 30 days | x | .10 | = | 3 days |
| Observatory Vibration Test | Component damage | 45 days | x | .20 | = | 9 days |
| Observatory EMI Test | Noise anomaly | 40 days | x | .60 | = | 24 days |
| Thermal Vacuum Test | Instrument failure | 80 days | x | .50 | = | 40 days |

*Starting Point for Reserve Determination* → 76 days

# Schedule Forecasting:
## *what is the predicted future schedule performance?*

### NBT Project Schedule Performance – as of May 30, 2002




| | Oct '01 | Nov '01 | Dec '01 | Jan '02 | Feb '02 | Mar '02 | Apr '02 | May '02 | Jun '02 | Jul '02 | Aug '02 | Sep '02 | Oct '02 | Nov '02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CUM Baseline** | 1 | 2 | 3 | 6 | 11 | 22 | 32 | 45 | 53 | 59 | 62 | 65 | 70 | 72 |
| **CUM Actual** | 1 | 3 | 7 | 7 | 8 | 9 | 12 | 16 | | | | | | |
| **CUM Forecast** | | | | | | | | | 23 | 30 | 40 | 57 | 66 | 72 |

# Projection Based on Efficiency-To-Date

**ASTRO Project Software Module Code & Checkout Completion: As of 5/31/02**

| | 2001 | | | 2002 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov |
| **CUM Baseline** | 1 | 2 | 3 | 6 | 11 | 22 | 32 | 40 | 50 | 59 | 62 | 65 | 67 | 70 |
| **CUM Actual** | 1 | 3 | 7 | 7 | 8 | 15 | 24 | 30 | | | | | | |
| **CUM Forecast** | | | | | | | | | 37 | 46 | 52 | 60 | 66 | 70 |

**TO DATE**

30 modules ÷ 8 months = 3.75 (actual rate)

40 modules ÷ 8 months = 5 (baseline rate)

3.75 ÷ 5 = 75% efficiency-to-date

**TO GO**

Actual rate to date = 3.75 modules

40 modules ÷ 6 months = 6.7 (forecast rate)

6.7 ÷ 3.75 = 178% efficiency-to-complete !

0% - - - - - - - - - - 50% - - - - - - - - - - 100%

Less Efficient More Efficient

***To date, schedule efficiency is 75%. To go, the forecast-to-complete efficiency of 178% is probably unrealistic - unless something has changed (e.g. new technical approach, add more programmers, descope work, etc.)***

# "What-If" Schedule Analysis:
## *how will changes affect the schedule?*

**"What-If" Schedule**

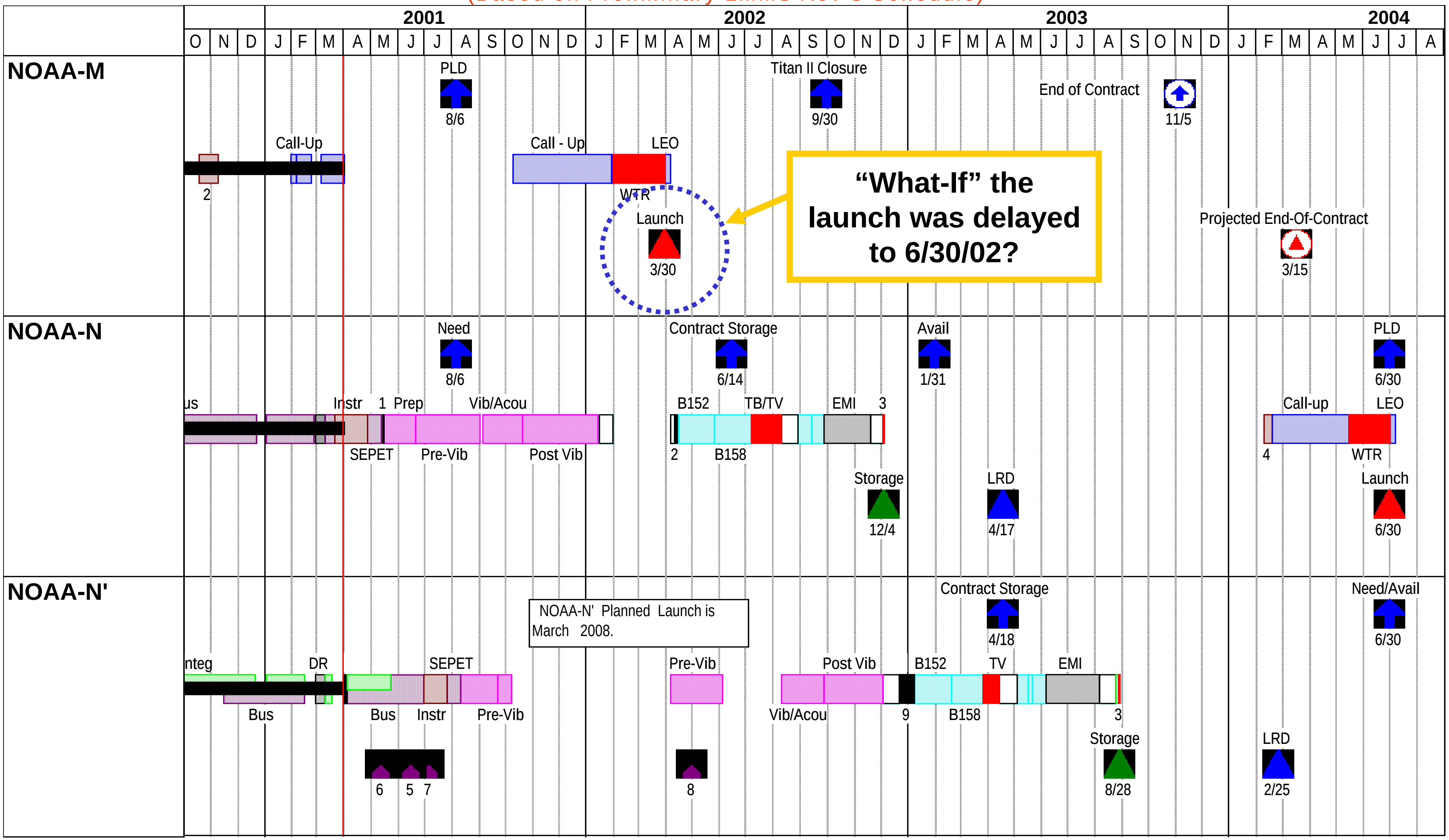
- **Projects the effect on the baseline or current operating schedule of a potential problem, new constraint, or changed assumption**
- **Provides the project team with insight into the impact of potential changes on the project's schedule objectives**

**Analysis Approach**

- **Develop a "What-If" schedule by modifying the baseline and/or current operating schedule to reflect a desired schedule change**
- **Examples:**
  - *- Change a key assumption*
  - *- Late parts or GFE delivery*
  - *- Descope of work*
  - *- Funding shortfalls*
  - *- Staffing shortages*

# NOAA M-N' I&T Summary Schedule As of 3/31/01

(Based on Preliminary LMMS Rev S Schedule)

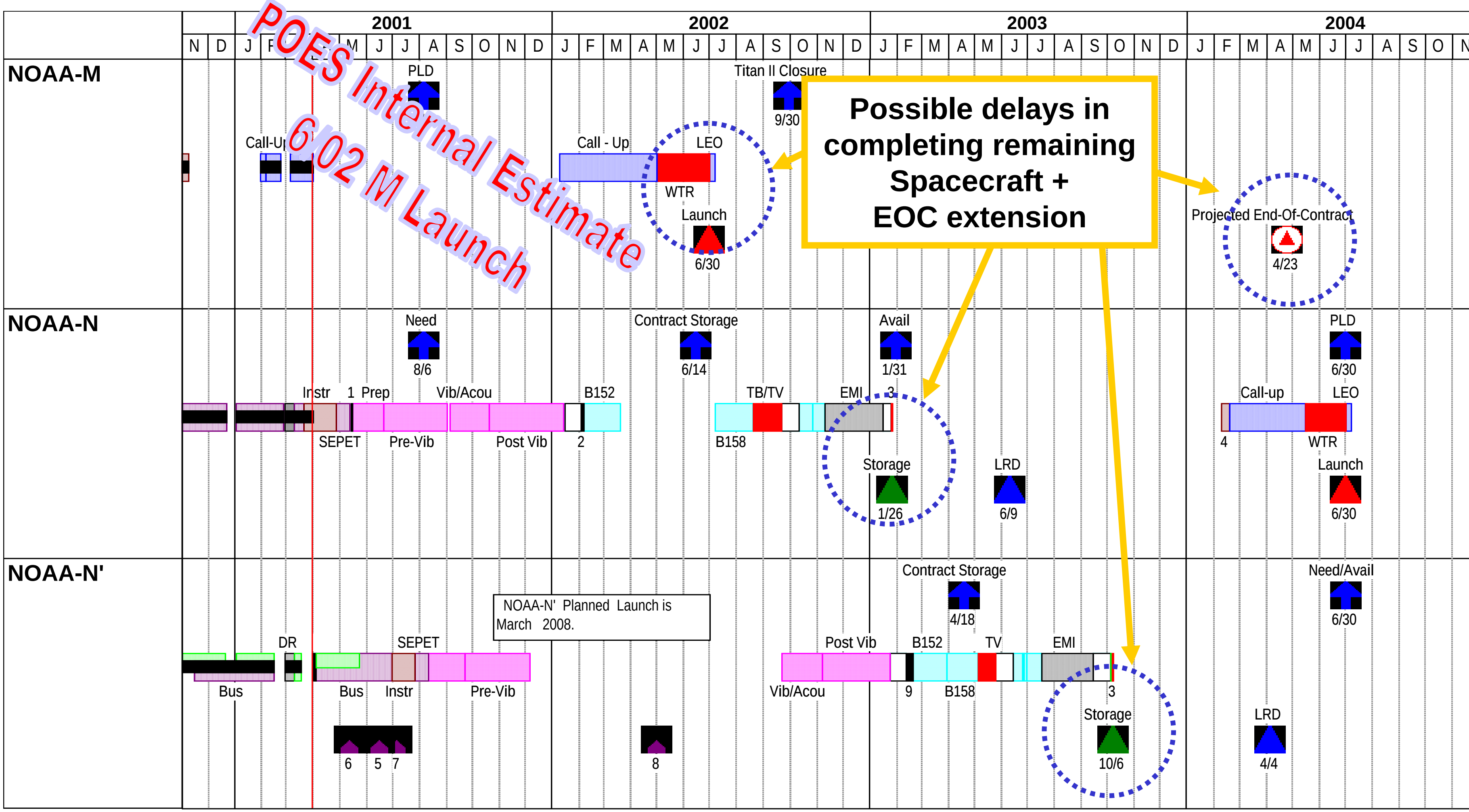



* = Not yet in LMMS Master Schedule

Foot Notes:
1. A303 Removal; Installation of Mass Models*
2. A303 Re-Integration & IPF/DET*
3. SEM & SBUV* Removal
4. SEM & SBUV* Re-Integration
5. SARR Delivery 6/15/01
6. A303 Installation on N' 5/13/01
7. SBUV Delivery 7/6/01
8. SARP/ADCS Delivery 4/30/02
9. SARP & ADCS Integration*

# NOAA M-N' I&T Summary Schedule: 6/30/02 M Launch

(Based on Preliminary LMMS Rev S Schedule)




Foot Notes:

1. SEM, SBUV, AVHRR & H303 Removal
2. SEM, SBUV, AVHRR & H303 Re-Integration
3. A303 Removal; Installation of Mass Model*
4. A303 Re-Integration & IPF/DET*
5. SEM & SBUV* Removal
6. SEM & SBUV* Re-Integration
7. SARP & ADCS Software Upgrades*
8. SARP/ADCS Delivery 4/30/02
9. SARP & ADCS Integration*

* = Not yet in LMMS Master Schedule

# NOAA-M Launch From VAFB, CA – 6/24/02

# Schedule Risk Analysis:

## *what is the likelihood of overrunning the schedule?*

**Risk:** a threat or uncertainty that could adversely impact the project's schedule objectives

**Analysis Approach:**

- **Project Risk Listing:** multi-disciplined subgroup of the project team lists and ranks qualitative or "gut feel" risks based on past experience early in the project life cycle
- **Formal Risk Management Systems:** establish and track schedule risks with parameters using alert zones or thresholds that when triggered lead to corrective action planning
- **Simulation Analysis:** mathematical modeling which translates the uncertainties associated with activity durations into their potential impact on the project's overall duration and schedule objectives ("Monte Carlo" technique)

# Quantifying Schedule Risk

- Could a range of duration estimates help us quantify schedule risk?

| | Activity Duration Estimates - Work Days | | | |
|---|---|---|---|---|
| Activity | Network Duration | Low Estimate | High Estimate | Average/ Expected |
| Design | 30.00 | 10.00 | 60.00 | 33.33 |
| Fab & Assy | 40.00 | 20.00 | 75.00 | 45.00 |
| I&T | 20.00 | 15.00 | 40.00 | 25.00 |
| | | | | |
| Total | 90.00 | 45.00 | 175.00 | 103.33 |

Example Project with 3 serial activities

- The difference between the most likely duration (*used in the logic network*) and the average/expected duration computed from the distribution is expressed as a potential overrun or delay:

103.33 – 90 = 13.33 work days of potential overrun

# Resource Analysis:
## *have resources been considered?*

**Duration**
Number of work periods or length of time needed for available resources to do the work

**Work**
Amount of effort needed to accomplish an activity

**Resources**
People, equipment, facilities, etc. needed to perform the work

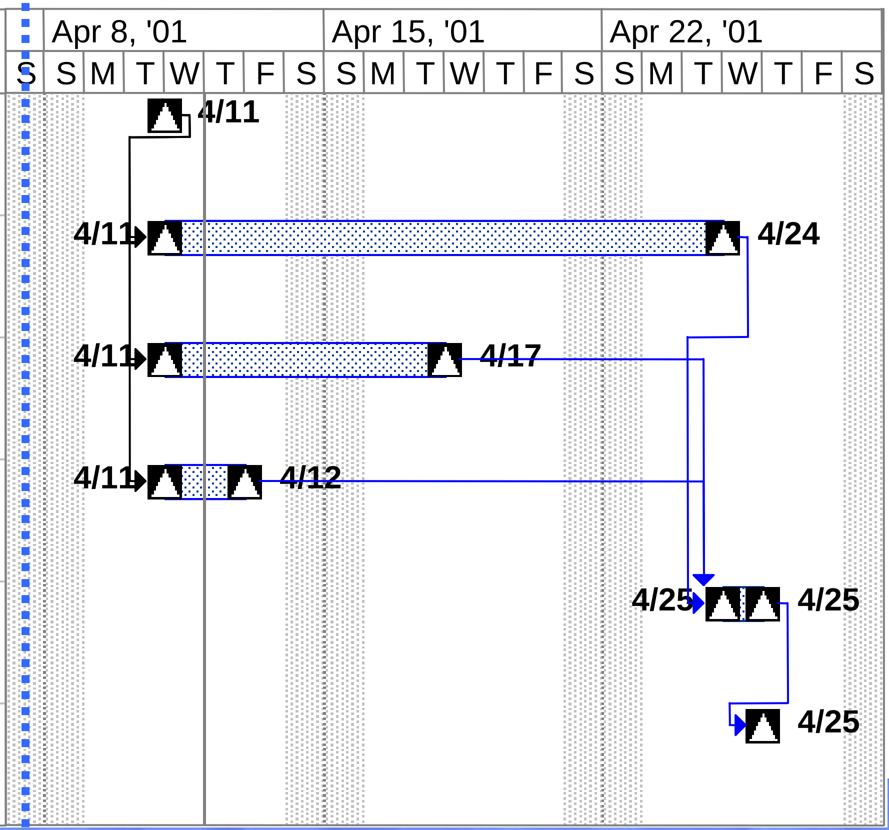
**Realistic schedules must account for resource availability – which help define an accurate cost estimate and budget.**

# Resource Identification & Allocation

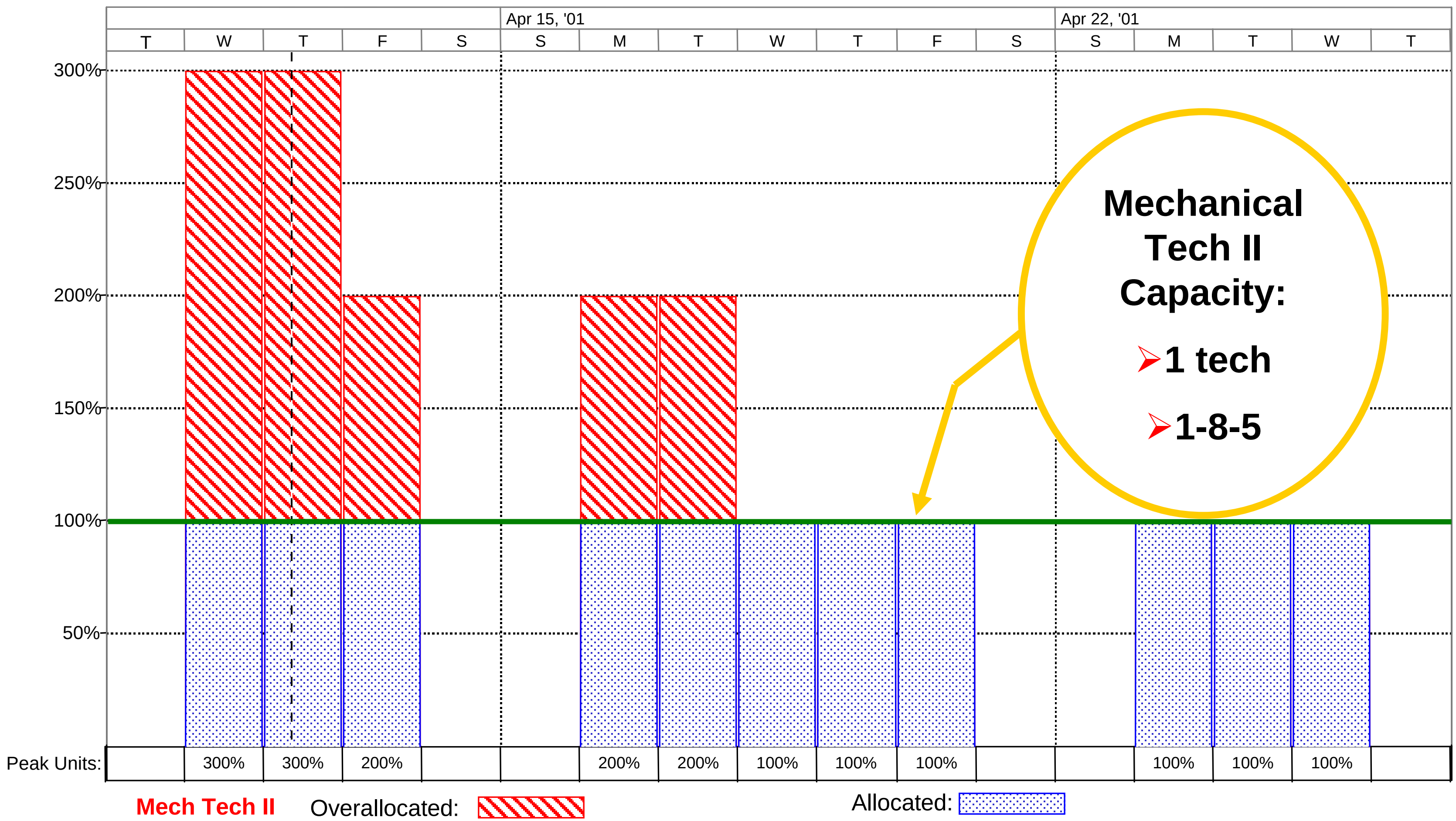
**Resource Identification:** **the selection and definition of resource categories that are needed to accomplish the project's activities (e.g. people, equipment, funds)**

**Resource Allocation:** **assigning and "loading" activities with the amounts of resources estimated to accomplish them**

| ID | Task Name | Duration | Work | Resource |
|---|---|---|---|---|
| 1 | Award Contract | 0 days? | 0 hrs | |
| 2 | Fab Housing | 10 days? | 80 hrs | Mech Tech II |
| 3 | Fab Side Panels | 5 days? | 40 hrs | Mech Tech II |
| 4 | Prep Module | 2 days? | 16 hrs | Mech Tech II |
| 5 | Assemble Unit | 1 day? | 8 hrs | Mech Tech II |
| 6 | Deliver Unit | 0 days? | 0 hrs | |



# Initial Resource Profile



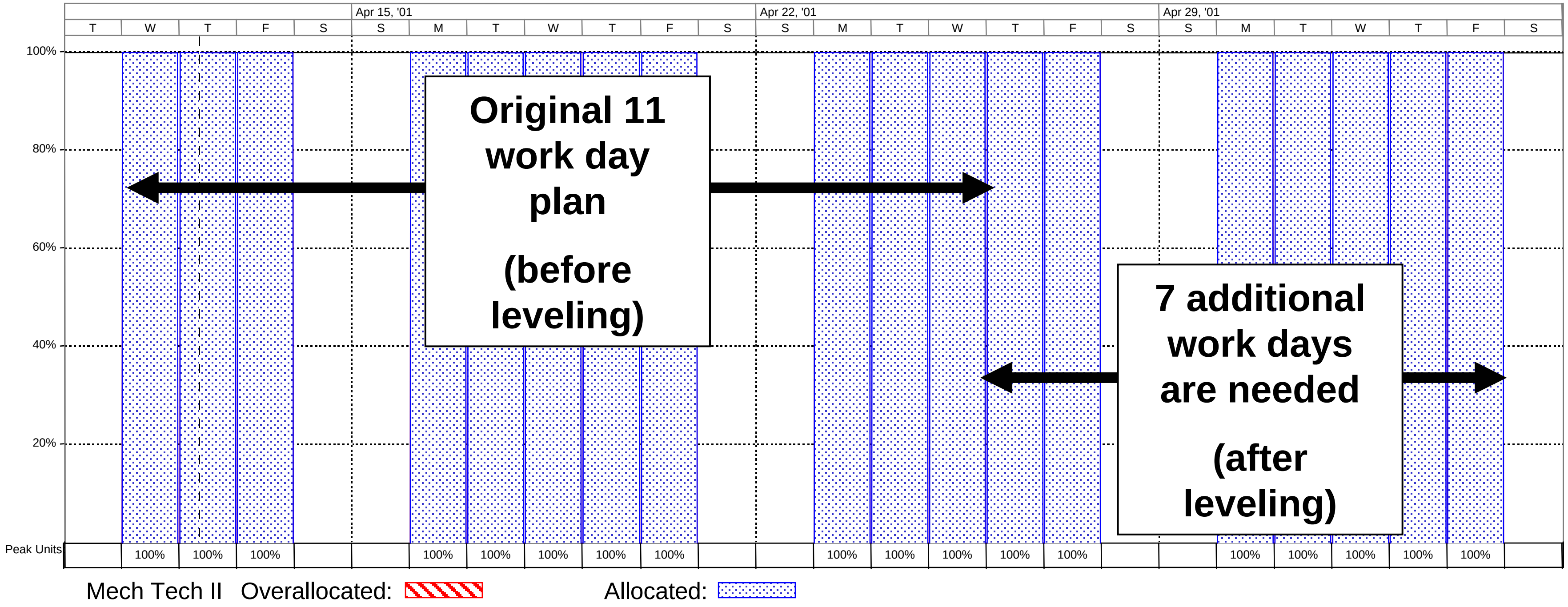

**The shortage or over-commitment of resources is determined by profiling the requested resources and comparing them to their availability or capacity.**

# Resource Analysis

- **Resource Analysis: resolution of inconsistencies between resource supply and demand in a specific period of time including:**
  - *Add more of the resource (e.g. 2nd shift)*
  - *Find a substitute for the resource (e.g. subcontract)*
  - *Delay some activities (examine free slack)*
  - *Perform some activities earlier than planned (examine logic)*
  - *Combination of the above*

- **Resource Leveling: the “smoothing” of resources so planned utilization matches availability in the most efficient manner while still meeting the project schedule’s objectives if possible**
  - *Schedule slack is a key consideration in leveling*
  - *Leveling most useful for critical, near-term activities*

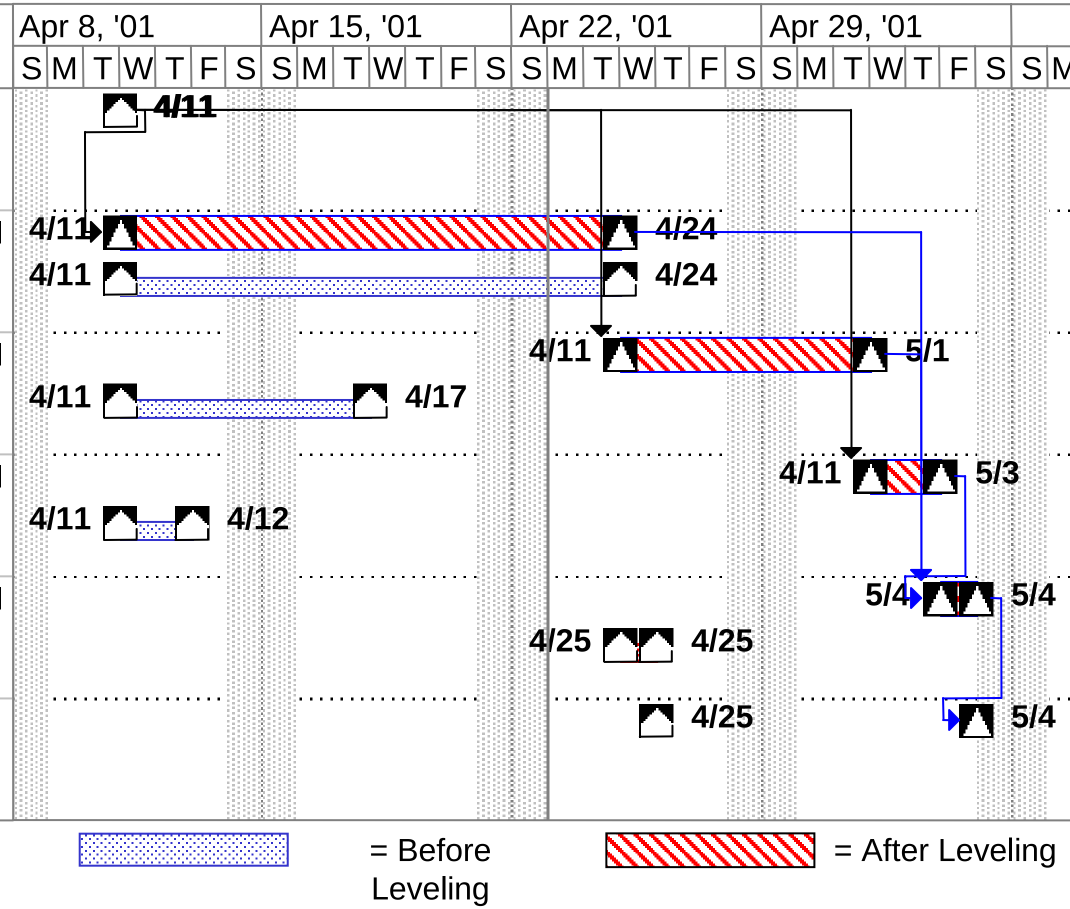
# “Leveled” Resource Profile




**The “leveling” or smoothing of the “Mechanical Tech II” resource allocation to fit the available capacity of one MTII.**

# Resource-Constrained Schedule

| ID | Task Name | Duration | Work | Resource |
|---|---|---|---|---|
| 1 | Award Contract | 0 days | 0 hrs | |
| 2 | Fab Housing | 10 days | 80 hrs | Mech Tech II |
| 3 | Fab Side Panels | 5 days | 40 hrs | Mech Tech II |
| 4 | Prep Module | 2 days | 16 hrs | Mech Tech II |
| 5 | Assemble Unit | 1 day | 8 hrs | Mech Tech II |
| 6 | Deliver Unit | 0 days | 0 hrs | |




**"Leveling" the resources results in a more realistic schedule, but delivery <u>cannot</u> occur on 4/25/01 as currently planned.**

# Summary

- **A baseline schedule is just a starting point**
- **Project teams need information to help keep things on track in order to meet objectives**
- **Schedule analysis techniques can augment earned value analysis by:**
  - ***Evaluating schedule results***
  - ***Assessing the magnitude, impact, and significance of actual and forecast variations to the baseline schedule and/or current operating schedule***